رواف ـــــد
RAWAFID
for TECHNOLOGY
للتكنولوجيا

www.r4t.me

TECHNICAL PROPOSAL

Data Acquisition Systems

"منظومات إختزال البيانات"

شركة روافد للتكنولوجيا (ذ.م.م): ص.ب. ٤١٨٤٩ أبو ظبي – الإمارات العربية المتحدة
ص.ب. ١٦٦٠ عشار/ البصرة - العراق

Prepared by Rawafid for Technology (R4T) L.L.C.
PO Box 41849, Abu Dhabi – UAE

24-12-2009

"منظومات إختزال البيانات"

تعرف منظومة إختزال البيانات كونها مجموعة من أجهزة تعمل على قراءة عوامل فيزيائية (إشارات كهربائية ناتجة عن قراءات طبيعية تتعلق مثلا بالضغط أو الحرارة أو الإضاءة أو المغناطيسية أو الصوت أو مستويات أرتفاع وأنخفاض وإنحناء أو سرعة في تعجيل أو تباطؤ ... ألخ) أو عوامل كيميائية (إشارات كهربائية ناتجة عن قراءات طبيعية تتعلق مثلا بشدة اللزوجة أو الحامضية أو حرارة تفاعل ... ألخ). وبعد قراءة البيانات يجب أن تتولى المنظومة عرضها (وتقديمها) لتتم الفائدة من قراءتها عبر قرارات تنفذ من قبل البشر المستخدمين أو عبر منظومات التحكم والسيطرة الآلية الأخرى.

وقبل إستخدام الأجهزة المحوسبة كانت قراءة البيانات تسجل في العادة على ألواح ورقية تطورت إلى مخططات بيانية ورسوم تنجزها أجهزة راسمة (Plotters) تستخدم لفائف وصفحات خاصة. وكان بعد ذلك على المهندسين معايرة (Calibration) تلك القراءات من أجل الضبط والمقايسة لقراءة السلوك الفيزيائي أو الكيميائي للبيئة المعروضة للقياس. وبعد إستخدام الأجهزة الالكترونية المتطورة ظهرت أجهزة قارئات البيانات (Data Loggers) التي تقوم بخزن القراءات الصادرة من أجهزة تحسس (Sensors). حيث تقوم الأخيرة بتحويل العوامل الفيزيائية أو الكيميائية المُتَحسَسَة إلى إشارات كهربائية تتولى القارئات تنظيم خزنها على أقراص ممغنطة. وبالتالي يمكن الرجوع إلى تلك البيانات في أي وقت آخر من أجل الغايات المطلوبة.

وبقدوم التطور الملحوظ في هندسة الحواسيب الرقمية أصبحت منظومات أختزال البيانات واحدة من ساحات التطبيق في مجال هندسة الحواسيب وأصبحت تشمل آليا تجميع البيانات القادمة من المتُحسِسات وتحويلها إلى الشكل الرقمي (واحد أو صفر) ثم خزنها لتقديمها إلى منظومة الحاسب الذي يتولى تحليلها ومعالجتها وفق برامج خاصة موضوعة للأغراض التي من أجلها تم أختزال تلك البيانات. وهكذا تكون منظومة الحاسب لإختزال البيانات متكونة في الأساس من المتحسسات والقارئات الخاصة (Sensors and Transducers) للإشارات القادمة إلى المنظومة، ثم أجهزة تكييف تلك الإشارات (من حيث التصفية والتضخيم أو التكبير وعزل غير المرغوب فيها وطرق تمريرها)، إضافة إلى أجهزة مساعدة أخرى وبرمجيات تطبيقية خاصة.

وإذ يبين هذا المقترح تقنية هذه المنظومات فأنه كذلك يقدم بإيجاز مثال لحالة خاصة تتعلق بإجزاء من منظومة إختزال تتولى قراءة بيانات بئر تنقيب نفطي يحيط به في العادة أجهزة ضغط هواء وضخ رغوات وإسترجاع أطيان يجب معالجتها. ولا تتطرق الحالة لكامل الأجزاء المستخدمة في مثل هذا التطبيق ولا للبرمجيات الملحقة بالمنظومة لإن ذلك يختلف بإختلاف الشركات المصنعة للأجهزة (المحوسبة) التي ترافق المنظومة في العادة.

للإطلاع على المقترحات الأخرى لشركة روافد للتكنولوجيا: تصفح الموقع الألكتروني

Email: md@r4t.me

Table of Contents

1. Introduction

First generation data acquisition is the practice of collecting and storing data from sensors or other measurements equipment. Technically, data acquisition techniques could include manual monitoring and recording methods, such as visually inspecting a device or measuring an object, but it generally refers to the use of electronic sensors and data collection equipment. Prior to the use of computerized hardware, data was often recorded on paper. Strip chart recorders and plotters would take an input signal and convert that signal to the one or two dimensional motion of a pen on a sheet or roll of paper. It was up to the operator to calibrate the scale of the output recordings on the graphs to accurately reflect the behavior being monitored.

The second generation of data acquisition equipment included data loggers, which were electronic systems that could store electronic from connected sensors and then either replay that data later via a paper chart recorder or by connection to a computer, such as a serial cable. Some data loggers evolved to include floppy drives so data could be recorded to a floppy disk then transferred to a computer. Finally the advent of computer based data acquisition allowed users to perform complex measurements and to store and retrieve data electronically.

Now days, DataAcQuisition (DAQ) system involves gathering signals from measurement sources and digitizing them for storage, analysis, and presentation on a PC. DAQ systems come in many different PC technology forms for great flexibility. Scientists and Engineers can choose from PCI (Peripheral Component Interconnect), PXI (PCI eXtensions for Instrumentation), PCMCIA (Personal Computer Memory Card International Association), USB (Universal Serial Bus), wireless and Ethernet data acquisition systems for test measurement and automation application.

There are five components to be considered while building a basic DAQ system:

i) Transducers & Sensors
ii) Signals
iii) Signals Conditioning
iv) DAQ Hardware
v) Drivers & Applications software

The purpose of data acquisition is to measure an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound. PC-based data acquisition uses a combination of modular hardware, application software, and a computer to take measurements. While each data acquisition system is defined by its application requirements, every system shares a common goal of acquiring, analyzing, and presenting information. Data acquisition systems incorporate signals, sensors, actuators, signal conditioning, data acquisition devices, and application software.

2. Product Details

DAQ system consists of three main components:

2.1 Operation System

The operation system is software that is considered the heart of the DAQ and its main function includes:

i) Human Machine Interface.
ii) Telemetry & Monitoring.
iii) Alarms & Fault Management.
iv) Logging & History.

2.2 Hardware Platform

This component includes Remote Site Equipments like PLCs, Sensors etc. and central site hardware like Personal Computers.

2.3 Communication Network

The nerve connecting all parts of the system is its communication network. DAQ systems may utilize all the available technologies including: wired, wireless, fiber, & internet.

3. Advantages

The advantages of Data Acquisition System are:

i) The computer can record and store a very large amount of data.
ii) The data can be displayed in any way the user requires.
iii) Thousands of sensors over a wide area can be connected to the system.
iv) The operator can incorporate real data simulations into the system.
v) Many types of data can be collected from the RTUs.
vi) The data can be viewed from anywhere, not just on site.

DAQ System can be utilized to achieve:

a) Increase Efficiency through: Minimizing Fault Response, Reducing Planned Down times, or Isolating and Precisely Locating Faults.

b) Maximize Profitability through: Reducing Failures / Unplanned down times, Reducing Operations Overhead, Reducing Manpower requirement, or Maximizing equipment life time.

4. Facts

Since their introduction in the mid-1970's, microprocessor-based data acquisition systems have been used to improve safety and reduce costs. Recent advances in hardware and software technology now enable designers to develop data acquisition systems which are more powerful, accurate, and reliable than previously possible.

With Supervisory Control And Data Acquisition (SCADA) systems, the Central Monitoring System (CMS) or Master Terminal Unit (MTU) receives inputs from Remote Terminal Units (RTUs) that are connected to field instrumentation such as process ovens. When polled by the SCADA master, the RTUs transmit data to the central host for processing. SCADA then logs alarms and displays the data graphically.

5. Types of Data Acquisition System

5.1 Wireless Data Acquisition Systems

Wireless data acquisition systems can eliminate costly and time consuming field wiring of process sensors. These systems consist of one or more wireless transmitters sending data back to a wireless receiver connected to a remote computer. Wireless transmitters are available for ambient temperature and relative humidity, thermocouples, RTDs, pulse output sensors, 4 to 20 mA transmitters and voltage output transducers. Receivers can be connected to the USB or Ethernet port on the PC.

Wireless Thermocouple Connector System

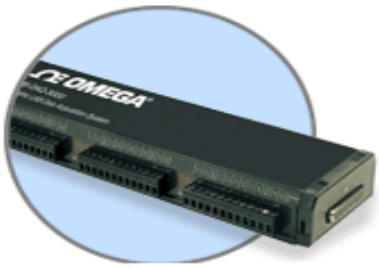
5.2 Serial Communication Data Acquisition Systems

Serial communcation data acquisition systems are a good choice when the measurement needs to be made at a location which is distant from the computer. There are several different communication standards, RS232 is the most common but only supports transmission distances up to 50 feet. RS485 is superior to RS485 and supports transmission distances to 5,000 feet.

Serial Port
Data Acquisition System

5.3 USB Data Acquisition Systems

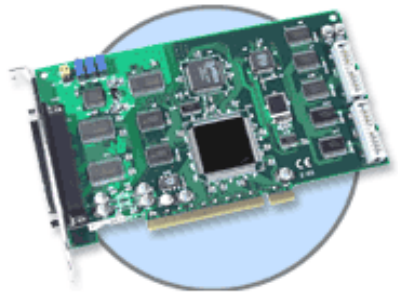
The Universal Serial Bus (USB) is standard for connecting PCs to peripheral devices such as printers, monitors, modems and data acquistion devices. USB offers several advantages over conventional serial and parallel connections, including higher bandwidth (up to 12 Mbits/s) and the ability to provide power to the peripheral device. USB is ideal for data acquisition applications. Since USB connections supply power, only one cable is required to link the data acquisition device to the PC, which most likely has at least one USB port.



USB
Data Acquisition Modules

5.4 Data Acquisition Plug-in Boards

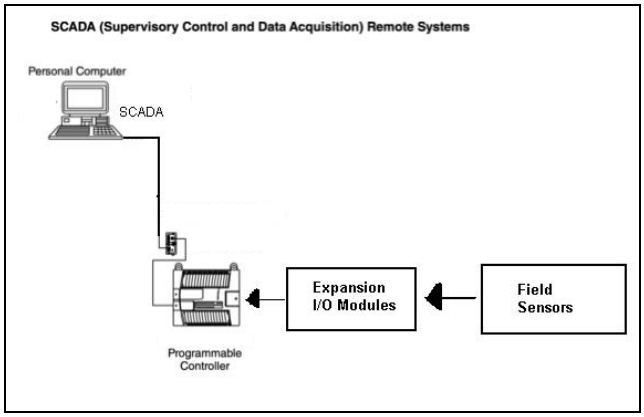
Computer data acquisition boards plug directly into the computer bus. Advantages of using boards are speed (because they are connected directly to the bus) and cost (because the overhead of packaging and power is provided by the computer). Boards offered are primarily for IBM PC and compatible computers. Features provided by the cards can vary due to number and type of inputs (voltage, thermocouple, on/off), outputs, speed and other functions provided. Each board installed in the computer is addressed at a unique Input/Output map location. The I/O map in the computer provides the address locations the processor uses to gain access to the specific device as required by its program.

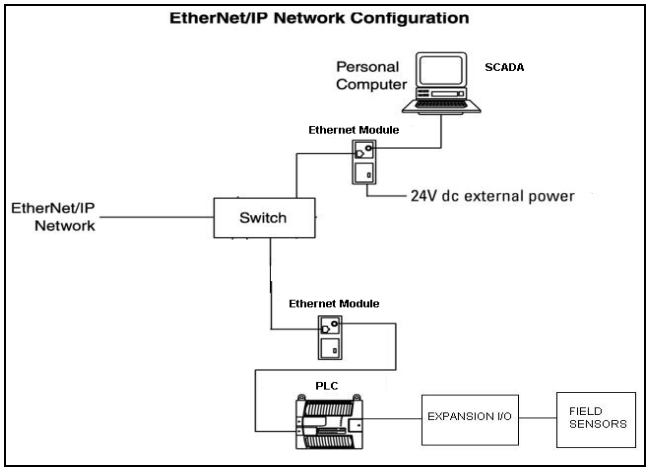


Data Acquisition Plug-in Boards

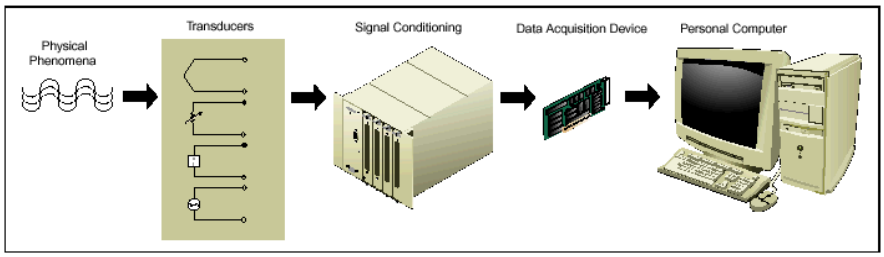
6. Architecture

A possible configurable architecture for a conventional data acquisition system is shown below in the following figure. The second figure here shows how a possible local area network can be extended using Ethernet protocol technology.





7. System Components



7.1 Transducers

Data acquisition begins with the physical phenomenon to be measured. This physical phenomenon could be the temperature of a room, the intensity of a light source, the pressure inside a chamber, the force applied to an object, or many other things. An effective DAQ system can measure all of these different-phenomena.

A transducer is a device that converts a physical phenomenon into a measurable electrical signal, such as voltage or current. The ability of a DAQ system to measure different phenomena depends on the transducers to convert the physical phenomena into signals measurable by the DAQ hardware. Transducers are synonymous with sensors in DAQ systems. There are specific transducers for many different applications, such as measuring temperature, pressure, or fluid flow. Figure below shows a short list of some common phenomena and the transducers used to measure them.

Phenomenon	Transducer
Temperature	Thermocouple, RTD, Thermistor
Light	Photo Sensor
Sound	Microphone
Force and Pressure	Strain Gage Piezoelectric Transducer
Position and Displacement	Potentiometer, LVDT, Optical Encoder
Acceleration	Accelerometer
pH	pH Electrode

Electrical Characteristics and Basic Signal Conditioning Requirements of Common Transducers

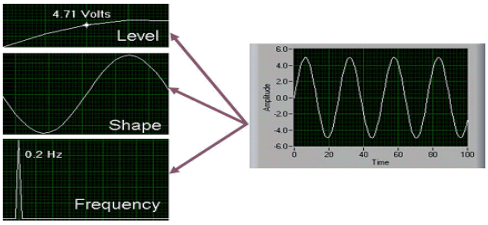
Sensor	Electrical Characteristics	Signal Conditioning Requirement
Thermocouple	Low-voltage output Low sensitivity Nonlinear output	Reference temperature sensor (for cold-junction compensation) High amplification Linearization
RTD	Low resistance (100 ohms typical) Low sensitivity Nonlinear output	Current excitation Four-wire/three-wire configuration Linearization
Strain gauge	Low resistance device Low sensitivity Nonlinear output	Voltage or current excitation High amplification Bridge completion Linearization Shunt calibration
Current output device	Current loop output (4 -- 20 mA typical)	Precision resistor
Thermistor	Resistive device High resistance and sensitivity Very nonlinear output	Current excitation or voltage excitation with reference resistor Linearization
Active Accelerometers	High-level voltage or current output Linear output	Power source Moderate amplification
AC Linear Variable Differential Transformer (LVDT)	AC voltage output	AC excitation Demodulation Linearization

7.2 Signals

The appropriate transducers convert physical phenomena into measurable signals. However, different signals need to be measured in different ways. For this reason, it is important to understand the different types of signals and their corresponding attributes. Signals can be categorized into two groups that are analog or digital.

7.2.1 Analog Signals

An analog signal can be at any value with respect to time. A few examples of analog signals include voltage, temperature, pressure, sound, and load. The three primary characteristics of an analog signal include level, shape, and frequency:



a) Level

Because analog signals can take on any value, the level gives vital information about the measured analog signal. The intensity of a light source, the temperature in a room, and the pressure inside a chamber are all examples that demonstrate the importance of the level of a signal. When measuring the level of a signal, the signal generally does not change quickly with respect to time. The accuracy of the measurement, how ever is very important. A DAQ system that yields maximum accuracy should be chosen to aid in analog level measurements.

b) Shape

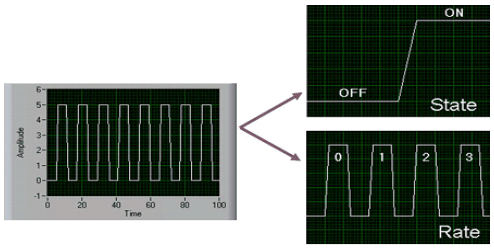
Some signals are named after their specific shape - sine, square, saw tooth, and triangle. The shape of an analog signal can be as important as the level, because by measuring the shape of an analog signal, you can further analyze the signal, including peak values, DC values, and slope. Signals where shape is of interest generally change rapidly with respect to time, but system accuracy is still important. The analysis of heartbeats, video signals, sounds, vibrations, and circuit responses are some applications involving shape measurements.

c) Frequency

All analog signals can be categorized by their frequency. Unlike the level or shape of the signal, frequency cannot be directly measured. The signal must be analyzed using software to determine the frequency information. This analysis is usually done using an algorithm known as the Fourier transform.

7.2.2 Digital Signals

A digital signal cannot take on any value with respect to time. Instead, a digital signal has two possible levels: high and low. Digital signals generally conform to certain specifications that define characteristics of the signal. Digital signals are commonly referred to as transistor-to-transistor logic (TTL). The useful information that can be measured from a digital signal includes the state and the rate:



a) State

Digital signals cannot take on any value with respect to time. The state of a digital signal is essentially the level of the signal - on or off, high or low. Monitoring the state of a switch - open or closed - is a common application showing the importance of knowing the state of a digital signal.

b) Rate

The rate of a digital signal defines how the digital signal changes state with respect to time. An example of measuring the rate of a digital signal includes determining how fast a motor shaft spins. Unlike frequency, the rate of a digital signal measures how often a portion of a signal occurs. A software algorithm is not required to determine the rate of a signal.

8. Signals Conditioning

Computer-based measurement systems are used in a wide variety of applications. In laboratories, in field services and on manufacturing plant floors, these systems act as general-purpose measurement tools well suited for measuring voltage signals. However, many real-world sensors and transducers require signal conditioning before a computer-based measurement system can effectively and accurately acquire the signal. The front-end signal conditioning system can include functions such as signal amplification, attenuation, filtering, electrical isolation, simultaneous sampling, and multiplexing. In addition, many transducers require excitation currents or voltages, bridge completion, linearization, or high amplification for proper and accurate operation. Therefore most computer based measurement systems include some form of signal conditioning in addition to DAQ devices.

In addition, transducers sometimes generate signals too difficult or too dangerous to measure directly with a DAQ device. For instance, when dealing with high voltages, noisy environments, extreme high and low signals, or simultaneous signal measurement, signal conditioning is essential for an effective DAQ system. Signal conditioning maximizes the accuracy of a system, allows sensors to operate properly, and guarantees safety.

It is important to select the right hardware for signal conditioning. Signal conditioning is offered in both modular and integrated forms. Regardless of the types of sensors or transducers you are using, the proper signal conditioning equipment can improve the quality and performance of your system.

Signal conditioning accessories can be used in a variety of applications including:

8.1 Amplification

Real-world signals are often very small in magnitude. Therefore, signals conditioning can improve the accuracy of the data. Amplifiers boost the level of the input signal to better match the range of the analog-to-digital converter (ADC), thus increasing the resolution and sensitivity of the measurement. While many DAQ devices include onboard amplifiers for this reason, many transducers, such as thermocouples, require additional amplification.

In addition, using external signal conditioners located closer to the signal source, or transducer, improves the signal-to-noise ratio of the measurement by boosting the signal level before it is affected by environmental noise.

8.2 Attenuation

Attenuation is the opposite of amplification. It is necessary when the voltages to be digitized are beyond the input range of the digitizer. This form of signal conditioning diminishes the amplitude of the input signal so that the conditioned signal is within range of the ADC. Attenuation is necessary for measuring high voltages.

8.3 Isolation

Improper grounding of the system is one of the most common causes for measurement problems, including noise and damaged measurement devices. Signal conditioners with isolation can prevent most of these problems. Such devices pass the signal from its source to the measurement device without a physical connection by using transformer, optical, or capacitive coupling techniques. Besides breaking ground loops, isolation blocks high-voltage surges and rejects high common-mode voltage and thus protects both the operators and expensive measurement equipment.

8.4 Filtering

Signal conditioners can include filters to reject unwanted noise within a certain frequency range. Almost all DAQ applications are subject to some level of 50 or 60 Hz noise picked up from power lines or machinery. Therefore, most conditioners include low pass filters designed specifically to provide maximum rejection of 50Hz to 60Hz.

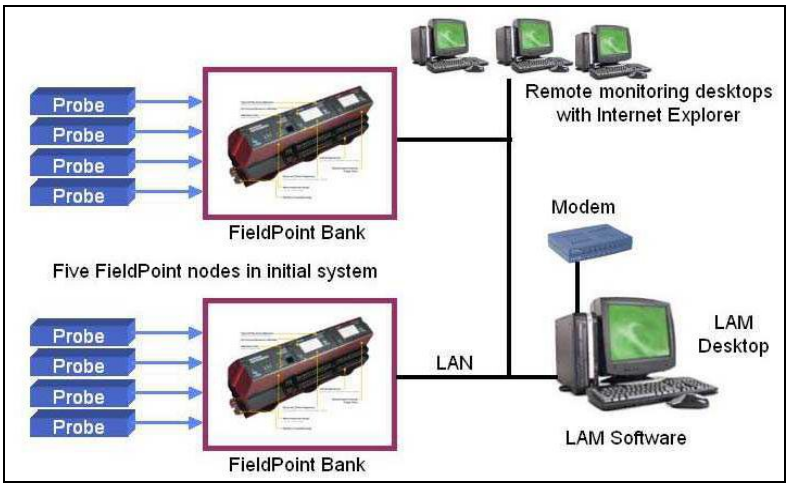
8.5 Multiplexing

By multiplexing, several signals can be sequentially routed into a single digitizer, thus achieving a cost-effective way to greatly expand the signal count of the system.

9. Field Points

Field Point is a distributed measurement system for monitoring or controlling signals in light industrial applications. A FieldPoint system includes a serial or Ethernet network module with several I/O modules in a bank. Each I/O module can measure eight or 16 channels. FieldPoint is designed for applications with small clusters of I/O points at several different locations.

FieldPoint is also an attractive solution for cost-sensitive applications performing low-speed-monitoring.



System features include:

- Modular architecture.
- Expandability.
- Integration that combines analog input, analog output, digital I/O, and switching into a single, unified platform.
- Low-speed monitoring.
- Light-industrial temperature range, hot-swappable, programmable start-up states, watchdog timers, etc.

10. Summary and Conclusion

Data acquisition systems, as the name implies, are products and/or processes used to collect information to document or analyze some phenomenon. The DAQ system accepts signals from a large number of sensors (rotary RPM, depth, pump pressure, temperature and Flow). The values measured by these sensors are displayed in several graphical screens and used to calculate other important derived parameters. In the simplest form, a technician logging the temperature of an oven on a piece of paper is performing data acquisition. As technology has progressed, this type of process has been simplified and made more accurate, versatile, and reliable through electronic equipment. Equipment ranges from simple recorders to sophisticated computer systems.

Appendix: DAQ Case Study

A1. Statement of Work

The case describes the implementation of ruggedized data acquisition system for use by drilling contractors on both offshore and onshore drilling rigs. A basic data acquisition system is considered to consist of sensors, signal conditioning and data gathering equipment, as well as means for data storage and archiving. An essential part is also a display system that shows the acquired data scaled to useful units, either graphically as a function of time or depth, or in other suitable ways. A complete measurement system also contains auxiliary equipment such as uninterrupted power supplies (UPS), cabling and connectors, data back-up equipment, and spare parts as well as manual routines for maintenance, calibrations, user support, etc

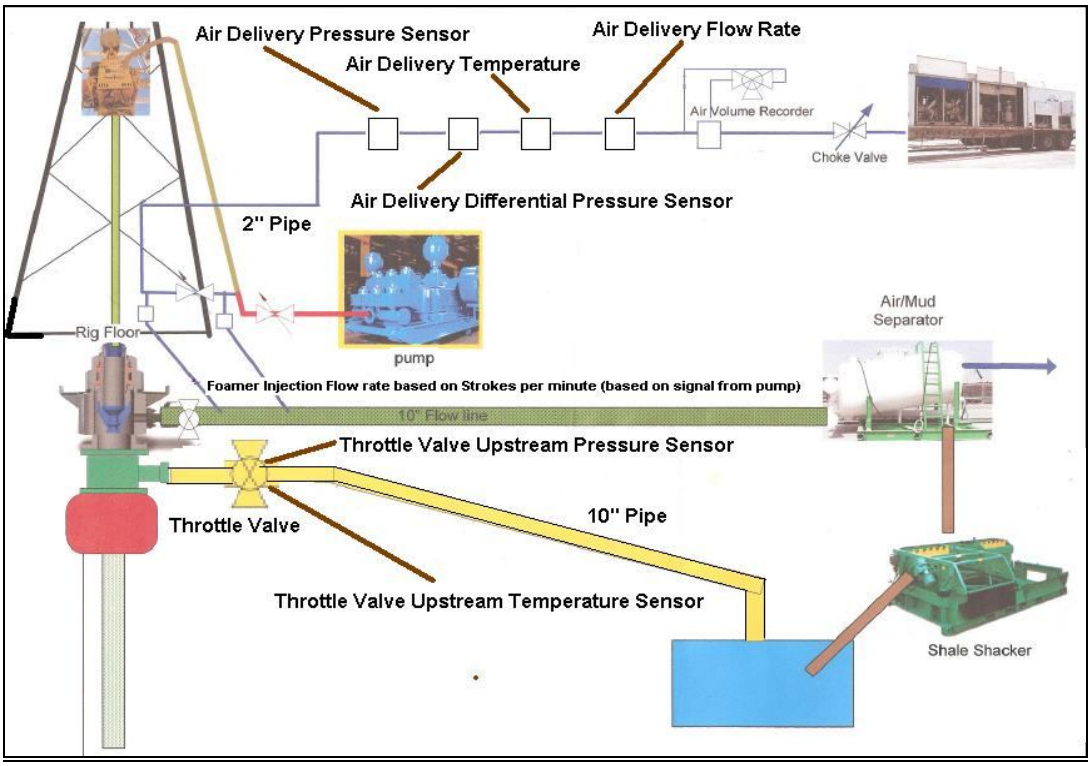
The data acquired from the drill rig while drilling, test data from the initial evaluation of the well as well as from long-term preproduction tests all benefit from being acquired and stored in an automatic on-site system, preferably displayed in real-time.

A2. Client Requirements

One Data Acquisition system, computer system with the ability to display continuous real time data and to record and log data on a variable periodic time base. The system must have the ability to interface with standard LAN, Hardwired or wireless network.

Parameters to be displayed and recorded include, but shall not be limited to:

1. Air Delivery Pressure.
2. Air Delivery Differential Pressure.
3. Air Delivery Temperature.
4. Air Delivery Flow Rate.
5. Foamer injection flow rate based on strokes per minute.
6. Well Head/High pressure Blooie Line Spool (Upstream of throttle Valve).
7. Well Head/Temperature Blooie Line Spool (Upstream of throttle Valve).



A3. Bill of Quantity

Item	Description	Quant.	Unit
1.	Air Delivery Pressure Sensor To be installed on a 2” Pipe line Analog Signal Maximum Pressure: 3000 PSI	1	No.
2.	Air Delivery Differential Pressure Sensor To be installed on a 2” Pipe line Digital Signal Maximum Pressure: 3000 PSI	1	No.
3.	Air Delivery Temperature To be installed on a 2” Pipe line Analog Signal Maximum Temperature: 100° C	1	No.
4.	Air Delivery Flow Rate To be installed on a 2” Pipe line Analog Signal	1	No.

	Maximum Flow: 1000 to 1200 CFM *(Cubic Feet per Minute)* Minimum Flow: To be detailed		
5.	Foamer Injection flow rate based on strokes per minute of Foam pump Analog Signal (0 – 10V)	1	No.
6.	Well head pressure upstream of throttle valve on 10" pipe line Analog Signal	1	No.
7.	Well head temperature upstream of throttle valve on 10" pipe line Analog Signal	1	No.
8.	Data Acquisition System complete with Display, record and log data with software.	1	No.

A4. Sensor Signals

SENSOR SIGNAL DETAILS	
Air Delivery Pressure	Analog
Air Delivery Differential Pressure	Digital
Air Delivery Temperature	Analog
Air Delivery Flow rate	Analog
Foamer Injection flow rate based on strokes per minute of Foam pump	Analog
Well head pressure upstream of throttle valve	Analog
Well head temperature upstream of throttle valve	Analog

A5. WebLAM

WebLAM is a distributed data acquisition, logging and alarm management system providing monitoring logging and Alarm management application in multi-user mode. The system consists of several sensors (probes). These are connected to Field Point embedded controller. The number of Field Point's can be more than one. These Field Point units are connected over LAN to a main server. The server provides services to users over Internet. Remote user can connect to the server computer through their browsers. The server PC can contact registered users through a modem.

The system can monitor following types of inputs:

1- Temperature probes (RTD, Thermistors, Thermocouples)
2- Sensor inputs (Voltage and Current)
3- Digital I/O

WebLAM enables flexible operation for any number of sensors spread over LAN connected to a server that can be accessed to monitor and configure the system through Internet. The system is controlled by an administrator that can

1. Add/delete users to the system
2. Set user privileges
3. Assign/Un-assign probes to users

WebLAM alarm notifications can be sent through: Email, Phone, Pager, or Skype for example.

A built in alarm escalation mechanism is provided that sends secondary notifications if the alarm remains un-acknowledged for a predefined notification buffer interval.